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QUARTZ CRYSTAL, STRONTIUM, WOLLASTONITE, AND ZEOLITES

By Joyce A. Ober, Michael J. Potter, and Robert L. Virta

1988

U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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Manuel Lujan, Jr.
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Director

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COVER PHOTO:
Total consumption of quartz crystal, strontium, wollastonite, and zeolites is small when compared to that of many other minerals, but all possess unique properties that make them important in specific applications. The minerals shown are, from left, two pieces of celestite, a strontium ore; a wollastonite specimen; three types of natural zeolites; and several types of quartz crystal, including natural, synthetic, lascas, and crystal blanks.

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QUARTZ CRYSTAL[1]

Cultured quartz crystal production and consumption increased in 1988 for the second consecutive year, although consumption of domestic lascas as feedstock for cultured quartz crystal decreased. The single domestic producer of lascas resumed mining and also supplied material to consumers from company stocks. Imports of lascas from Brazil increased. Demand for specimen-quality natural quartz continued at a high level; quartz crystal for this application is discussed in the Gem Stone chapter.

Domestic Data Coverage

Domestic production and consumption data for quartz crystal are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the seven companies canvassed for the production of cultured quartz crystal, all responded, and the six active operations represented 100% of total production shown in table 1. Of the 34 operations canvassed concerning consumption of quartz crystal, 30 responded, 2 of which were not active. These companies represented nearly 100% of total consumption, also shown in table 1. Consumption for the nonrespondents was estimated using reported prior-year consumption levels.

Legislation and Government Programs

The National Defense Stockpile contained 1.8 million pounds of natural quartz crystal, valued at $11 million. This quantity represented an excess of 1.2 million pounds above the goal set for the stockpile. Near yearend, authority for disposal of this excess was established, and studies were being conducted to evaluate the impact of releasing the surplus stocks into the market. The stockpile material, which primarily consists of large natural crystals, could be absorbed by the specimen and gem material industry. Very little, if any, of the material would be consumed in the same applications as synthetic quartz crystal.

Domestic Production

Coleman Quartz Inc., Jessieville, AR, the only domestic company known to produce lascas, supplied the feed material for cultured quartz crystal from mine production and from company stocks.

Production of cultured quartz crystal increased slightly in 1988. Six companies were active. The two largest producers, Sawyer Research Products Inc. of Eastlake, OH, and Thermo Dynamics Corp. of Merriam, KS, were independent growers that produced crystal bars for domestic and foreign consumers in the crystal device fabrication industry. Motorola Inc. of Chicago, IL, and Electro Dynamics Corp. of Overland Park, KS, produced quartz crystal for both internal consumption and the domestic device fabrication industry. P. R. Hoffman Material Processing Co. of Carlysle, PA, also reported outside sales. Bliley Electric Co. of Erie, PA, produced only for internal consumption.

Consumption and Uses

Consumption of lascas by the six domestic quartz crystal producers decreased about 10%, from 1.1 million pounds in 1987 to 1.0 million pounds in 1988. The 32 active device fabricating

TABLE 1

SALIENT U.S. ELECTRONIC- AND OPTICAL-GRADE QUARTZ CRYSTAL STATISTICS

(Thousand pounds and thousand dollars)

	1984	1985	1986	1987	1988
Production:					
Mine[e,1]	2,500	1,000	1,200	—	600
Cultured	1,027	568	524	840	857
Exports:					
Natural:[2]					
Quantity	42	60	74	139	95
Value	$234	$290	$411	$708	$431
Cultured:[2]					
Quantity	277	185	324	448	417
Value	$11,021	$3,723	$5,686	$6,954	$7,162
Lascas:					
Quantity[e]	1,600	800	—	—	—
Imports of lascas:[3]					
Quantity	569	173	52	146	215
Value	$373	$99	$51	$157	$180
Consumption:					
Natural (electronic and optical-grade)	7	7	2	(4)	3
Cultured (lumbered)	77	44	43	55	62
Cultured (as grown)	391	224	428	552	646
Total	**475**	**275**	**473**	**607**	**711**

[e] Estimated.
[1] Excludes lascas produced for specimen and jewelry material uses.
[2] Bureau of the Census as adjusted by the Bureau of Mines.
[3] Bureau of the Census.
[4] Less than 1/2 unit.

companies in 11 States consumed 17% more quartz crystal in 1988 than in 1987. Of these companies, 30 consumed only cultured quartz crystal and 1 consumed both natural and cultured crystal. One company consumed only natural quartz crystal.

A small amount of imported natural quartz crystal continued to be required as seed material for growing cultured quartz. Cultured quartz crystal was used to make very accurate electronic timing devices. The crystals can be found in watches and clocks; in microprocessors in industrial, automotive, and consumer products; and in military, aerospace, and commercial electronic devices requiring very high selectivity and stability.

Stocks

Crystal growers' stocks of as-grown cultured quartz crystal were reported as 188,000 pounds at the beginning of 1988. At yearend, these stocks had decreased to 111,000 pounds.

Prices

The price for domestic lascas reported by Coleman Quartz was $0.40 per pound. The customs value of Brazilian lascas increased 33% to $1.26 per pound. Material from Namibia that was used for feedstock was imported as quartzite rather than lascas, and the customs value was $0.29 per pound. The average value of as-grown cultured quartz, based on reported sales of about 615,000 pounds, was $8.77 per pound, a decrease of 31% compared with that of 1987. Sales volume increased 21%. The average value of lumbered quartz, as-grown quartz that has been processed by sawing and grinding, decreased 6% to $54.53 per pound, based on reported sales of 140,000 pounds. Sales volume increased 18%.

Foreign Trade

Cultured quartz crystal exports, as reported by the Bureau of the Census, decreased 7% in 1988 to 416,974 pounds. The average f.a.s. value was $17.18 per pound, an 11% increase compared with exports in 1987. The Republic of Korea was the largest customer for this material, accounting for 208,582 pounds or 50% of cultured quartz crystal exports from the United States. The destination for 95,258 pounds, 23% of exported U.S. cultured quartz crystal, was Japan.

Imports of feedstock material including Brazilian lascas, designated as "Crude Brazilian Pebble," and quartzite from Namibia, both of which are used as feedstock for the domestic synthetic producers, increased 47% to 215,255 pounds with a customs value of $180,095.

STRONTIUM[2]

Demand for strontium minerals and compounds increased for the second consecutive year. Imports of celestite, a strontium ore consisting of at least 90% strontium sulfate, increased, indicating expanded domestic production of strontium compounds. Imports of most strontium compounds also grew. Chemical Products Corp. (CPC) of Cartersville, GA, was the only U.S. producer of strontium compounds from celestite. CPC produced compounds from imported material because there were no active celestite mines in the United States.

Domestic Data Coverage

Domestic production data for strontium are voluntarily provided to the Bureau of Mines by the sole U.S. producer. Production and stock data are withheld from publication to avoid disclosing company proprietary data.

The Bureau also calculates the distribution of strontium compounds by end use. Of the 10 operations to which a survey request was sent, 8 responded. The information collected from this survey represents nearly 100% of the end-use data shown in table 2. Consumption for the nonrespondents was estimated using reported prior-year consumption levels.

Domestic Production

CPC was the only domestic producer of strontium carbonate and strontium nitrate from imported celestite. Mallinkrodt Inc. of St. Louis, MO, produced strontium chloride and Mineral Pigments Corp. of Beltsville, MD, produced strontium chromate. A few other companies produced downstream strontium compounds but on a very small scale.

Consumption and Uses

The largest end use for strontium was in the manufacture of faceplate glass for color television picture tubes. Strontium, which is supplied as strontium carbonate and converted to strontium oxide during the manufacturing process, blocks X-ray emissions from the picture tube during operation of the television set. Strontium carbonate demand for this end use continued to be high. About two-thirds of all domestic strontium consumption is in television picture tube production.

Another expanding end use for strontium is strontium ferrites. These compounds are produced by heating a mixture of strontium carbonate and iron oxide. The resulting material is formed into permanent ceramic magnets that are used in fractional horsepower motors for automobile accessories, loudspeakers, computers, and other electronic equipment.

Use of strontium nitrate in pyrotechnics and signals was considered to be a mature but steady market. Strontium nitrate creates a brilliant red flame when it burns.

Smaller amounts of strontium compounds are used in a variety of applications. Strontium carbonate was used to remove lead from electrolytically refined zinc. Strontium chromate was used as a corrosion inhibitor in pigments and paint, strontium phosphate was used in fluorescent lights, and

strontium chloride was an active ingredient in toothpaste for sensitive teeth. Strontium metal was used to improve castability of aluminum for use in the automobile industry. Strontium oxide was one of the materials used in high-temperature superconductor research.

Prices

The average customs value for celestite imported from Mexico was about $70 per short ton. Ore imported from Spain had a customs value of $172 per ton. Very small amounts of celestite were reported from France and the Federal Republic of Germany. The weighted average value for all imported strontium minerals was about $77 per ton. This value represented a decrease of about 10% from the average customs value reported for 1987. Values of imported strontium compounds varied according to the type of compound and the country of origin.

Foreign Trade

According to the Journal of Commerce Port Import/Export Reporting Service, U.S. exports of strontium compounds were about 6,500 tons, an increase of 86% over the exports reported in 1987. Of these exports, 89% was strontium carbonate that went to Japan, the world's leading consumer of strontium compounds. Other strontium compounds exported were chromate, ferrite, nitrate, oxalate, and phosphate, all in relatively small quantities.

According to the Bureau of the Census, the Federal Republic of Germany remained the most important source of imported strontium compounds, with Mexico nearly as important. Imports of strontium carbonate, precipitated and not precipitated, increased about 88%, with imports from Mexico more than three times the level reported in 1987. Imports of strontium nitrate decreased about 71%, the second consecutive year with significant decreases in imports. Canada, was once again the major supplier of strontium metal, although imports decreased about 8%.

World Capacity

The data in table 5 are annual rated capacity for chemical processing plants as of December 31, 1988. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Two types of strontium capacity exist, ore production capacity and compound production capacity. Strontium compound capacity was deemed the more important for several reasons. Essentially all strontium is consumed in compound form, primarily as the carbonate and to a lesser extent as the nitrate. Strontium carbonate is also the intermediate product in production of downstream compounds. At least 12 countries mined celestite in 1988. Virtually all of the celestite mined annually is consumed in the production of strontium carbonate and other strontium compounds. Very little strontium was consumed directly in the mineral form.

Listing both ore and compound production capacity could be misleading, possibly resulting in double-counting of strontium capacity. Because most ore is produced for market by means of very simple sorting and beneficiation techniques, capacity can easily be raised to meet increased demand. Strontium carbonate production capacity is the limiting factor in strontium production, requiring complicated and sophisticated processing facilities. Therefore, stron-

TABLE 2

U.S. ESTIMATED DISTRIBUTION OF PRIMARY STRONTIUM COMPOUNDS, BY END USE

(Percent)

End use	1986	1987	1988
Electrolytic production of zinc	6	5	4
Ferrite ceramic magnets	11	11	11
Pigments and fillers	7	5	4
Pyrotechnics and signals	12	13	10
Television picture tubes	60	63	68
Other	4	3	3
Total	**100**	**100**	**100**

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM MINERALS,[1] BY COUNTRY

Country	1987		1988	
	Quantity (short tons)	Value[2] (thousands)	Quantity (short tons)	Value[2] (thousands)
China	297	$34	—	—
France	—	—	33	$9
Germany, Federal Republic of	—	—	37	29
Mexico	42,172	3,636	42,639	2,988
Spain	—	—	2,753	476
Total	**42,469**	**3,670**	**45,462**	**3,502**

[1] Celestite (strontium sulfate).
[2] Customs value.

Source: Bureau of the Census.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS AND METAL, BY COUNTRY

Country	1987		1988	
	Pounds	Value[1]	Pounds	Value[1]
Strontium carbonate, not precipitated:				
Germany, Federal Republic of	—	—	—	—
Mexico	44,092	$10,948	—	—
Spain	34,172	1,875	—	—
Total	**78,264**	**12,823**	**—**	**—**
Strontium carbonate, precipitated:				
Canada	—	—	39,683	$11,176
Germany, Federal Republic of	10,120,618	2,771,119	13,765,104	3,831,489
Italy	—	—	6,636	5,280
Japan	11,670	7,822	18,166	29,769
Mexico	4,263,566	1,139,916	13,332,424	3,122,012
United Kingdom	41,798	24,693	28,633	22,541
Total	**14,437,652**	**3,943,550**	**27,190,646**	**7,022,267**
Strontium chromate:[2]				
Australia	—	—	5,093	13,365
Belgium	21,826	23,760	54,275	83,080
Canada	29,765	41,509	14,000	17,923
France	160,932	186,625	138,889	181,945
Germany, Federal Republic of	39,684	44,843	39,600	44,748
Korea, Republic of	—	—	16,196	19,804
United Kingdom	10,400	10,776	—	—
Total	**262,607**	**307,513**	**268,053**	**360,865**
Strontium nitrate:				
Germany, Federal Republic of	1,357	8,220	—	—
Italy	1,183,671	455,589	272,076	175,028
Mexico	2,205	2,000	54,361	22,755
Spain	481,708	206,218	160,275	73,050
Total	**1,668,941**	**672,027**	**486,712**	**270,833**
Strontium compounds, other:				
Canada	3,489	31,956	93	1,284
France	—	—	97,369	158,334
Germany, Federal Republic of	6,614	8,129	53,127	132,519
Italy	—	—	2,633	1,169
Japan	546,742	1,206,432	495,057	457 535
Netherlands	148,546	150,299	40	4,680
United Kingdom	31,838	53,800	105,563	176,746
Total	**737,229**	**1,450,616**	**753,882**	**932,267**
Strontium salts (potassium oxalate and other):				
Belgium	—	—	2,772	7,000
Canada	—	—	44,533	7,960
China	37,478	1,253	—	—
Germany, Federal Republic of	6,614	7,891	—	—

See footnotes at end of table.

tium carbonate production capacity, reported in terms of contained strontium, was selected for tabulation.

Capacity data for the United States was estimated based on celestite imports, and assuming an 85% recovery of strontium from celestite containing a minimum ore grade of 90% strontium sulfate. Capacity information for other countries was compiled from published reports.

World Review

Corning Glass Works of the United States announced a joint venture with Asahi Glass Co. Ltd. of Japan to produce color television faceplate glass in Europe, Mexico, and the United States. Both companies are leaders in faceplate glass production and planned to share their technology. The glass manufactured as a result of this venture will require large quantities of strontium carbonate, thus further increasing global demand for this application.[3]

China.—The largest ore-dressing plant in China, with a capacity to produce 11,000 tons per year of celestite concentrate, was completed at the Nanjing strontium mine in the Jiang Su Province. Operations at the mine began in 1972 and the capacity expansion began in 1985. The goal of the project was to improve strontium recovery by modernizing the processing facility, as well as to increase production.[4]

Mexico.—Cía. Minera La Valenciana S.A. converted its strontium carbonate facilities to the black ash process from the soda ash process. The black ash process is capable of producing a higher quality strontium carbonate product. The company was also installing another kiln that would increase carbonate production capacity to about 24,000 tons per year when completed.[5] Sales y Oxidos, owned 51% by Mexican business interests and 49% by Church and Dwight Co. Inc. of Princeton, NJ, planned to double the strontium carbonate capacity at its facility

TABLE 4—Continued

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS AND METAL, BY COUNTRY

Country	1987		1988	
	Pounds	Value[1]	Pounds	Value[1]
Japan	—	—	1,323	$4,570
Switzerland	—	—	2,205	5,513
Total	**44,092**	**$9,144**	**50,833**	**25,043**
Strontium sulfate (other than celestite):				
Canada	—	—	42,000	2,843
Denmark	1	4,000	—	—
Germany, Federal Republic of	2,696,297	157,939	—	—
Total	**2,696,298**	**161,939**	**42,000**	**2,843**
Strontium metal, unwrought:				
Canada	82,724	747,805	75,711	694,973
Mexico	—	—	235	4,009
United Kingdom	11	1,131	—	—
Total	**82,735**	**748,936**	**75,946**	**698,982**

[1] Customs value.
[2] Imported as strontium chromate pigment (TSUS 473.19).

Source: Bureau of the Census.

TABLE 5

WORLD STRONTIUM CARBONATE ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 1988

(Short tons of contained strontium)

Country	Rated capacity[1]
North America:	
Mexico	12,500
United States[e 2 3]	15,000
Total	**27,500**
Europe:	
Germany, Federal Republic of[2]	9,800
Spain	5,200
U.S.S.R.	([4])
United Kingdom	([4])
Total	**15,000**
Asia:	
China	1,200
Japan[2]	20,000
Total	**21,200**
World total	**63,700**

[e] Estimated.
[1] Includes capacity at operating plants as well as plants on a standby basis.
[2] Production was entirely from imported celestite.
[3] Includes strontium nitrate production capacity.
[4] Strontium carbonate production capacity existed in these countries, but specific data were not available.

near Monterrey. The company was operating at capacity and produced about 8,000 tons of carbonate for export to Japan, the United States, and Europe, in decreasing order of importance.[6]

Spain.—The Aurora Mine, operated at the Montevive celestite deposit in the Province of Granada, was jointly owned by three families. Canteras Industriales S.A. mined celestite ore at this site using hand-sorting for beneficiation. The owners announced plans to install a mechanical washer that will raise the ore production capacity to 66,000 tons per year. Most of the production from this mine is exported to Japan and the Republic of Korea.[7]

Technology

Developments in high-definition television (HDTV) technology along with trends to larger, flatter picture tubes indicated that demand for strontium carbonate in these applications will continue to increase. One strontium producer suggested that the move toward HDTV prompted plans to increase celestite production capacity and to install additional strontium carbonate capacity.[8]

Research continued in the attempt to identify the best material or combination of materials for high-temperature superconductors. Superconductors lose all resistance to electricity at low temperatures, creating the potential for extremely efficient power transmission. New combinations of materials were discovered that possessed superconducting properties at temperatures higher than previously believed possible. High-purity strontium oxide was one superconducting compound mentioned in several research reports. It may be years, however, before the full benefits of high-temperature superconductors are fully realized.[9]

General Electric Co. of Schenectady, NY, developed a ceramic composite consisting of a matrix of strontium aluminum silicate with silicon carbide whisker and particulate reinforcement. The new composite material compared favorably with sintered and hot-pressed ceramics. Although it was not as strong as some forms of silicon carbide nor as resistant to high temperatures as alumina, it was shown to be more oxidation and corrosion resistant than carbides and more resistent to thermal shock than alumina. The improved process for forming the strontium aluminum silicate composite simplified the fabrication of complex shapes, required less energy, and thus cost less to manufacture than more traditional ceramics. The new composite may be useful in a wide variety of structural ceramic components employed at temperatures up to 1,000° C.[10]

TABLE 6

STRONTIUM MINERALS: WORLD PRODUCTION, BY COUNTRY[1]

(Short tons)

Country[2]	1984	1985	1986	1987[p]	1988[e]
Algeria[e]	6,000	6,000	6,000	6,000	6,000
Argentina	441	1,084	1,249	1,113	1,100
Cyprus (celestite)	—	1,543	8,119	6,945	5,500
Iran (celestite)[3]	r25,353	r22,046	24,251	e24,250	24,250
Italy	2,866	5,083	5,144	195	110
Mexico (celestite)	35,264	r35,627	26,502	52,623	49,600
Pakistan	622	791	1,099	1,194	1,200
Spain	r27,381	r43,101	38,030	r e44,100	44,100
Turkey[e]	38,600	38,600	38,600	38,600	[4]59,525
United Kingdom	r17,724	r25,396	16,247	24,973	19,800
Total	**r154,251**	**r179,271**	**165,241**	**199,993**	**211,185**

[e] Estimated. [p] Preliminary. [r] Revised.

[1] Table includes data available through June 7, 1989.

[2] In addition to the countries listed, China, Poland, and the U.S.S.R. produce strontium minerals, but output is not reported quantitatively, and available information is inadequate to make reliable estimates of output levels.

[3] Data are for year beginning Mar. 21 of that stated.

[4] Reported figure.

WOLLASTONITE[11]

Wollastonite is natural calcium silicate and has a theoretical composition of $CaO \cdot SiO_2$.

The tonnage of wollastonite sold or used by U.S. producers in 1988 increased slightly. Specific data were withheld to avoid disclosing company proprietary data. The two producers were NYCO, a division of Processed Minerals Inc., Essex County, NY, and R. T. Vanderbilt Co. Inc., Lewis County, NY.

Wollastonite is used as a filler in ceramic tile, paint, and plastics. It serves as an asbestos replacement in some applications such as a reinforcement filler for boards and panels in various heat containment applications including ovens, dryers, thermal ducting, and many other thermal applications. Wollastonite also replaces asbestos in certain cement formulations, in ceiling and floor tile, and in friction applications such as brake linings. NYCO introduced G-Wollastokup, a high-aspect-ratio reinforcement, which is a chemically modified wollastonite that can be a total or partial replacement for chopped and milled fiberglass up to ⅜-inch long.[12]

Prices from Industrial Minerals, December 1988, for wollastonite, ex-works, truck lots, per short ton, were $214 for acicular, minus 200 mesh, and $140 to $160 for 325 to 400 mesh. Prices per short ton for wollastonite, f.o.b. plant, 200 to 325 mesh, were $92 to $137 bulk and $110 to $155 bagged materials.

Alpine AG opened an extensive test center at its existing plant in Augsburg, Federal Republic of Germany. The center contained numerous machines and systems for mechanical process technology, including size reduction, air classification, sorting, and mixing. The test center was designed for applications testing in a variety of industries including minerals. Of particular interest to the minerals industry is testing of fluidized-bed, opposed-jet mills, Circoplex classifier mills, and Turboplex ultrafine classifiers for wollastonite and other industrial minerals.[13]

In Greece, successful drilling and beneficiation research were carried out by Mevior S.A. on a wollastonite deposit near Kimmeria. Proven reserves so far were about 500,000 tons of ore with approximately 50% recoverable wollastonite. Initial beneficiation tests with wet, high-intensity magnetic separation after flotation yielded 0.3% iron oxide, making the product suitable for the ceramics industry. The company planned to continue exploration drilling and build a pilot plant in 1988.[14]

Although wollastonite deposits occur in the States of Chihuahua, Morelos, Puebla, and Zacatecas in Mexico, the only production was in Zacatecas. Most of the output, ranging from 10,000 tons to 15,000 tons per year, was consumed domestically by the ceramics industry. Wollastonita de México S.A. mined material in La Blanca, and General de Minerales S.A. extracted wollastonite from two open pit operations at Santa Fe and Panfilo Natura, both 30 to 35 miles from Guadalupe, Zacatecas. Ore was processed at the company's Guadalupe plant to produce 3-inch, 0.5-inch, 0.25-inch, and 200-mesh products for use in ceramics.[15]

Synthetic wollastonite was one of the lime-containing minerals produced by Rheinische Kalksteinwerke GmbH in Wulfrath, Federal Republic of Germany. These minerals are characterized by analytical purity, low compositional variance, and modest loss on ignition. However, synthetic wollastonite cannot substitute for natural wollastonite when long-grain structure is important, such as in filler applications and asbestos replacement.

Feedstock for synthetic wollastonite contained mixtures of lime-containing raw materials such as calcium carbonate, calcium hydrate, and quicklime. These were mixed with quartz and fired in a kiln at 2,640° F or higher. Low-iron and extremely low-iron wollastonites were produced. Ceramic end uses included white glazes, earthenware, and vitrified, or glassy, bodies. Other applications were in welding powders and in casting pow-

ders for steelmaking, which are important in regulating the cast speed and surface condition of continuous-cast steel.[16]

ZEOLITES[17]

Seven companies mined and sold chabazite and clinoptilolite from deposits in five States. Production and sales were approximately 12,000 short tons. Natural zeolites were used for air purification, animal feed supplements, aquaculture, aquarium filters, chemical carriers, desiccants, pet litter, and wastewater cleanup.

The Bureau of Mines continued research on the use of zeolites to remove dissolved metals and other cations from waste and process water. The cation exchange capacities for Pb^{2+} were determined for clinoptilolite, erionite, mordenite, and phillipsite samples from 19 locations. Exchange capacities ranged from 0.4 to 2.1 milliequivalents per gram. Capacities were lower than predicted because of impurities in the zeolite structure or blockage of pores by foreign materials. Exchange capacities for other cations were determined for two of the clinoptilolite samples. The order of preferential adsorption was Pb^{2+}, K^{+}, Ca^{2+}, NH_4^{+}, Cd^{2+}, Cu^{2+}, Co^{2+}, Zn^{2+}, Ni^{2+}, and Hg^{2+}. Pretreatment of industrial wastewaters to remove calcium, which decreases a zeolite's capacity for heavy metals, also was investigated. Simulated tailing water was treated with soda ash. Pretreatment reduced the Ca^{2+} concentration from 390 parts per million to less than 8. Soda ash rather than lime was used to avoid introducing additional calcium into solution.

The stability of chabazite, clinoptilolite, erionite, and mordenite, which is important if they are to be used to remove heavy metals from acidic mine drainage or acidic industrial wastes, was investigated. The order of stability of the zeolites tested in acidic solutions (from pH of 0.75 to 5) was mordenite, clinoptilolite, erionite, and chabazite. Additional tests on the erionite sample indicated that the acidic solutions removed significant amounts of Na^{+} and Si^{4+} and smaller amounts of K^{+}, Fe^{n+}, Al^{3+}, and Ca^{2+} from the zeolite structure.[18]

Ammonium and zinc ions (NH_4^{+} and Zn^{2+}) are present in municipal wastewater and it is necessary to remove NH_4^{+} to avoid pollution of the ground water. The effectiveness of clinoptilolite and mordenite for removing NH_4^{+} from dilute solutions containing Zn^{2+} was investigated. Mordenite and clinoptilolite removed 2 to 10 times more NH_4^{+} than Zn^{2+} from dilute solutions containing 2 to 7 milliequivalents per liter. Mordenite had a larger cation exchange capacity for NH_4^{+} than clinoptilolite. The exchange capacities for Zn^{2+} were similar for both zeolites. Absorption of NH_4^{+} was not affected by the presence of Zn^{2+} in solution but Zn^{2+} absorption was lower when NH_4^{+} was present.[19]

A mineral additive consisting of approximately 60% clinoptilolite and mordenite (FMA) was investigated as a means of producing super-high-strength concrete. A 9:1 ratio of cement and FMA produced concrete having a higher compressive strength than concrete made with either a portland cement, a cement and fly-ash mixture, or a cement and slag powder mixture. Mixtures of cement and FMA in ratios ranging from 19:1 to 6:1 produced concrete with higher compressive strengths than concrete containing only portland cement. Water-reducing agents were recommended to improve the strengthening effect of FMA. Concrete strength improved because the FMA reduced the formation of calcium hydroxide and decreased the number of pores exceeding 1,000 angstroms in width.[20]

A photochemical technique was used to investigate chemical reactions that occur on the surface and within the crystal structure of faujasite and a pentasil zeolite. The zeolites were treated with organic chemicals and then irradiated. The irradiation caused the chemicals to react, and the products were extracted and analyzed. By determining the ratio of the different reaction products, information on the reactions that occurred within the structure could be determined.[21]

Union Carbide Corp. developed a new molecular sieve that effectively adsorbs a variety of organic molecules including organic acids, aldehydes, ketones, mercaptans, ammonia, and indole without strongly adsorbing water. The molecular sieve is insoluble in water and organic solvents, cannot be oxidized, is chemically nonreactive in most systems, and is stable up to 800° C. Potential applications include personal-care items and household odor control.[22]

The growth in the use of synthetic zeolites in detergents, although not as rapid as in Europe, has doubled since 1986 in response to widening bans on phosphate use in detergents. The annual consumption rate was estimated to be 85,000 to 95,000 tons.[23]

A joint venture between PQ Corp. and Shell Polymers and Catalysts Enterprises Inc. was formed to manufacture and sell zeolite catalysts. The zeolites will be synthesized at the PQ facility in Kansas City, KS.[24]

European zeolite consumption is increasing as detergent makers continue to replace phosphates with zeolites. The use of phosphates decreased because of public pressure to reduce water pollution. As a result, European zeolite producers planned new construction or began expansion of existing plants for synthesizing zeolites.[25]

A joint venture between Union Chimique Belge (UCB), Solvay et Cie. S.A. and Audiset S.p.A. was formed to renovate a UCB phosphoric acid facility. The refurbished facility will be capable of producing 44,000 tons per year of 4A zeolite. The zeolite will be sold primarily as a replacement for sodium tripolyphosphate in detergents. Solvay will supply the raw materials, UCB will provide the manufacturing facilities,

and Audiset will market the zeolites.[26]

Conteka BV, a joint venture between Northern Development Co. and Conteka Holding, invested over $16 million to build a new manufacturing facility in the Netherlands. The facility will produce zeolites for catalytic applications by the oil, petrochemical and other industries. The plant is scheduled to begin operation in 1989.[27]

TG Birac of Yugoslavia planned to double its production capacity by yearend from 110,000 tons per year to 220,000 tons per year. The company installed new drying units and made other modifications to the plant to improve the production capacity. The company sells zeolites to the detergent industry.[28]

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